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Abstract	This deliverable contains initial guidelines and tools for community engagement and monitoring as well as the research that led up to those. We showed how the six guidelines can increase participation: by increasing self-efficacy, allowing for social interaction between participants, focussing on recruitment, increasing diversity and accessibility, increasing appreciation and importance, and developing project framing. These guidelines can have an impact on various types of participation: they can be long-term and/or short-term, more people and/or more contributions, increased quality and/or increased quantity, and increasing participation of specific groups and/or anyone.
Keywords	Engagement, participation, citizen science, community

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EXECUTIVE SUMMARY

This document outlines initial guidelines and tools for community engagement and monitoring in citizen science, and describes the research that led up to the formulation of those guidelines. Based on a systematic literature review, interviews with citizens and project managers of a citizen science project, and feedback received during a workshop, we have formulated seven guidelines for having more people participate in citizen science projects. Following these guidelines is expected to increase participation, which can be long-term and/or short-term, more people and/or more contributions, increased quality and/or increased quantity, and increasing participation of specific groups and/or anyone. These guidelines specify how to increase self-efficacy, allow for social interaction between participants, improve recruitment, increase diversity and accessibility, increase appreciation and importance, and develop project framing.

These guidelines are for project managers of citizen science projects that want to increase participation, as well as researchers working on community engagement and participation in citizen science. A complementary audience is the ACTION consortium. Project managers of citizen science projects will find information on how to increase participation that fits the needs of their project, and understand the evidence base for those guidelines. Whereas references are made to actual practical interventions to increase participation, the main source for finding those practical interventions will be the tool in the ACTION toolkit that is based on the research in this deliverable (https://actionproject.eu/toolkit/).

Researchers working on community engagement and participation in citizen science will be interested to see the systematic literature review, which describes the state of the art of research done on motivation and participation in citizen science. They can also learn from a case study (the Dutch Butterfly Conservation), about how the framing of a citizen project influences participants' framing of that project and subsequently the way they engage and participate in the project. Last, the process by which the guidelines were developed and the future plans for turning these guidelines into a tool in the ACTION toolkit are outlined.

1 INTRODUCTION

Engaging a community of citizens is at the core of every citizen science project. As we can see in the participatory science lifecycle (figure 1), engaging citizens happens throughout the lifecycle of a citizen science project. It involves attracting a community, and maintaining it.

This deliverable provides initial guidelines and tools for community engagement and monitoring. In addition to these initial guidelines, this deliverable reports on research activities that have fed into these guidelines, and explains their connection. Final guidelines will be published in January 2022, based on further research and feedback on these initial guidelines.

There are various ways to approach community engagement. We have chosen a practical approach - that of *participation*. Participation is the practical translation of community engagement: a community that is engaged, participates in the project, and to increase participation is to increase engagement.

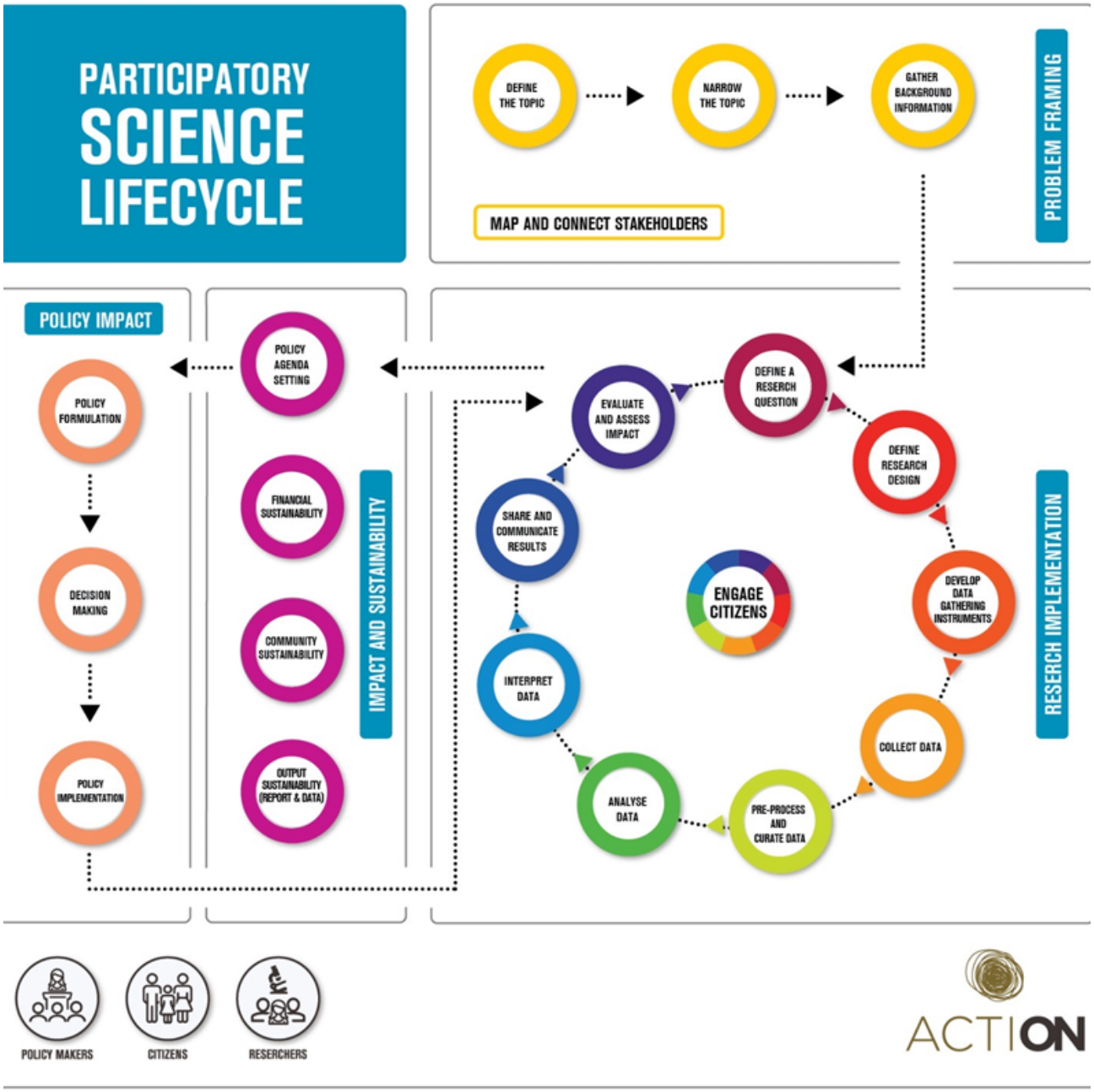

Figure 1: Participatory science lifecycle

Participation in citizen-science projects has several dimensions:

- It can be **short-term** or **long-term** participation. A citizen can solve one folding puzzle on the online platform Zooniverse, or they can count butterflies once a month for nine years.
- Increased participation can mean **more citizens**, or **more contributions per citizen**. When a project manager wants to increase the number of observations of plastic waste,

they can focus on attracting more volunteers, or on stimulating every volunteer to increase their observations (or both).
- Next to increasing the **quantity** of participation, a citizen science project might also want to increase the **quality** of contributions, for example by increasing the accuracy of the measurements of air pollution that the citizens record.
- Last, project managers might be interested to increase participation of **specific groups**, rather than of **anyone**. For example, a project might want to attract more young people, or increase participation of people living in a specific neighbourhood.

We will use these aspects of participation to structure the guidelines for increasing participation Some of the guidelines are targeted to increase participation of a specific kind. This will also translate into the tool for the toolkit that we will develop based on these guidelines (see chapter 5). In the next three chapters we will report on the research that has led to these guidelines: a systematic literature review (chapter 2), the analysis of a case study (chapter 3), and results from a workshop with citizen science managers (chapter 4).

2 SYSTEMATIC LITERATURE REVIEW

In this chapter, we discuss selected results of a systematic literature review. There are a number of existing systematic literature reviews on citizen science that cover specific aspects. Wehn & Almomani (2019) reviewed literature that used the Theory of Planned Behaviour, while Simperl et al (2018) systematically reviewed research on the use of gamification in citizen science. Gharesifard et al (2019) focus on community based monitoring initiatives of water and environment, and Kullenberg & Kasperowski (2016) on elucidating the concept and meaning of citizen science. However, there is a certain gap regarding a state of the art on why individuals participate in citizen science and how participation can be increased. Therefore, the research questions that were the focus of this literature review are: 1. Why do individuals participate in citizen science, and how can participation be increased?, and 2. What influences why people participate (project type, demographics, etc)?

The content of this literature review and of this deliverable in general is closely aligned to the topic of *motivation* in citizen science. It is often believed that by understanding and increasing the motivation of citizen scientists, we can increase their participation - for more information on motivation consult ACTION Deliverable 5.6 (Reeves N. et al. 2020). However, this link is not as straightforward as it seems, and is still much debated in the literature (Nakayama et al. 2019, Eveleigh et al. 2014). In ACTION, we treat motivation as a very specific research topic that only intersects the topic of participation and does not coincide with it.

2.1 Methods

We obtained the articles for the systematic literature review in three ways. First we performed a search on the SCOPUS database using the search terms “citizen science” AND “motivat*” OR “engagement”, in February 2020. We developed these search terms based on the recommendations by Snyder (2019). We tried alternative search terms, such as “participatory science”, based on terms identified by Kullenberg and Kasperowski (2016) in an analysis of citizen science, however we did not find any new or relevant articles. Based on prior knowledge of research on citizen science participation, we knew that some articles were not listed in the SCOPUS database, which is why we involved a second step. In this step, we conducted a manual search through all articles of the Citizen Science Theory and Practice Journal - the only dedicated journal for research on citizen science. Third, we followed a process called *back and forward snowballing* (Gharesifard et al. 2019; van Wee and Banister, 2016). This process works as follows: we performed a search of articles cited in the articles found in step one and two and included them in the list of articles. Furthermore, for all articles found thus far, we searched for articles that cited those articles, and added the new articles. We conducted this process until we found no new articles. Based on the 42 additional articles found using step 2 and 3, using forward and backwards snowballing was effective and necessary for finding articles not listed in the SCOPUS database.

For all three methods, we used a two-step selection process to determine if the article would be included. Snyder (2019) recommends reading article titles and abstracts first to rule out any research that is clearly irrelevant. Then a subsequent full reading of the article allows for the final selection of research to be included. The primary selection criteria for including articles in this review was that the research was relevant in answering the research questions of this literature review. Additionally, we only included research that collected primary data or used data from previous studies in novel ways. A few articles could not be assessed as access was not available. There were also a few articles with multiple versions, mostly a conference paper that was later published in a journal, in which case only the most recent version was included in the review. Conference papers were eligible for inclusion as they are often cited in the literature and one report (Geoghegan et al, 2016) was also included as it was often cited.

In total 156 articles were included in this literature review. 103 were obtained from the SCOPUS search, 11 from Citizen Science Practice and Theory, and 42 from citations. 121 were journal articles, 34 were conference papers and 1 was a report. Publication dates ranged from 2005 to 2020. We read the articles and recorded the primary findings relevant to the research questions of this literature review. We recorded further data on the sample size and sampling methods, and demographical data of participants.

2.2 Results

The following seven factors emerged as having a positive or negative influence on participation in a citizen science project: self-efficacy, demographics and bias, social factors, feedback, recruitment, task design, and barriers.

2.2.1 Self-efficacy

Several studies found that some citizen science participants **perceived anxiety** regarding performing their tasks correctly (Aristeidou et al. 2017; Eveleigh et al. 2014; and Segal et al. 2015). Participants may stop contributing due to worries that their mistakes will cause decreased quality of the results. Self-efficacy theory holds that the expected self-efficacy that an individual has for a task determines if they will participate and to what degree (Bandura, 1978).

Although few studies explicitly use self-efficacy theory, many studies support its premises (Jennett et al. 2016, Eveleigh et al. 2014). Several studies have found that **prior experience or training increases participation** (Golumbic et al. 2019b, Joseph et al. 2019, Carballo-Cárdenas and Tobi 2016, Parrish et al. 2018, Ng et al 2018, Frensley et al. 2017). Similarly, Martin et al. (2016) and Gharesifard and Wehn (2016) found that a perceived lack of knowledge was the most significant barrier to participation. These findings align with self-efficacy theory, in that feeling more confident about task performance can increase participation.

How can we increase self-efficacy? A few studies have tested increasing self-efficacy through **verbal persuasion**. Segal et al (2015) tested the ability to retain volunteers by sending emails that targeted self-efficacy (as well as previously identified motivations for joining). Participants received

an email that stated the collective nature of the projects, tolerance for individual mistakes, and the availability of other projects. This intervention increased continued participation from 6.7% to 9.7%. However, the control group did not receive an email at all, which makes it difficult to attribute the findings to receiving an email or the message within the email. Segal et al. (2018) similarly found that providing motivational and self-efficacy messages, such as “we use statistical techniques to get the most from every answer; So, you don’t need to worry about being ‘right’. Just tell us what you see” at the correct timing increased participation quantity by 69% compared to messages about the helpfulness of contributions.

Increasing self-efficacy does not only influence the **quantity of participation**. Van der Wal et al. (2016) found that providing feedback aimed at increasing the self-efficacy of participants can increase **long-term participation** and **quality of participation**. Rotman et al. (2014) similarly argue that considering self-efficacy is important for facilitating long term participation.

2.2.2 Demographics

The demographics of participants in citizen science seems to be **skewed in terms of age, income, education, gender, race, culture, and health**, see figure 2. Participants in citizen science projects are often well educated and older. Although a significant amount of studies find that there is a gender disbalance in the group of participants, the number of studies that find an overrepresentation of men, is equal to the number of studies that find an overrepresentation of women. This section outlines whether participants’ demographics influence why and how they participate.

Participants’ overrepresentation	**Studies**	**Total**
Older	Jakositz et al. 2020, He et al. 2019, Martin and Greig 2019, Dunkley 2019, Ganzevoort and Van Den Born 2019, García et al. 2019, Aucott et al. 2019, Ng et al. 2018, Richter et al. 2018, Lucrezi et al. 2018, Ganzevoort et al. 2017, Del Savio et al. 2017, Domroese and Johnson 2017, Merenlender et al. 2016, Land-Zandstra et al. 2016a, Alender 2016, Land-Zandstra et al. 2016b, Curtis 2015, Wright et al. 2015, Raddick et al. 2013, Grace-McCaskey et al. 2019, Larson et al. 2020, Frensley et al. 2017, Baruch et al. 2016, Crandall et al. 2018, Davis et al. 2019, Geoghegan et al. 2016	26

Younger	Noel-Storr 2019, Rappold et al. 2019, Dem et al. 2018, Johnson et al. 2014, Curtis 2018, Cooper et al. 2017, Krebs 2010	6
Higher income	Johnson et al. 2018, Domroese and Johnson 2017, Merenlender et al. 2016, Wright et al. 2015, Johnson et al. 2014, Larson et al. 2020, Frensley et al. 2017, Cox et al. 2018	8
Lower income	Geoghegan et al. 2016	1
Educated	Jakositz et al. 2020, Martin and Greig 2019, Dunkley 2019, Ganzevoort and Van Den Born 2019, Church et al. 2019, Golumbic et al. 2019b, Rappold et al. 2019, Ng et al. 2018, Johnson et al. 2018, Ganzevoort et al. 2017, Savio et al. 2017, Tiago et al. 2017, Domroese and Johnson 2017, Merenlender et al. 2016, Land-Zandstra et al. 2016a, Alender 2016, Curtis 2015, Wright et al. 2015, Johnson et al. 2014, Jordan Raddick et al. 2013, Koss et al. 2009, Grace-McCaskey et al. 2019, Larson et al. 2020, Bloom and Crowder 2020, Frensley et al. 2017, Curtis 2018, Cooper et al. 2017, Cox et al. 2018, Crandall et al. 2018, Davis et al. 2019, Evans et al. 2005	30
Female	Jakositz et al. 2020, He et al. 2019, Martin and Greig 2019, Joseph et al. 2019, Kimura 2019, Rappold et al. 2019, Meakin et al. 2019, Johnson et al. 2018, Domroese and Johnson 2017, Merenlender et al. 2016, Land-Zandstra et al. 2016b, Davis et al. 2019	12
Male	Dunkley 2019, Ganzevoort and Van Den Born 2019, Ganzevoort et al. 2017, Land-Zandstra et al. 2016a, Curtis 2015, Wright et al. 2015, Johnson et al. 2014, Jordan Raddick et al. 2013, Killion et al. 2018, Curtis 2018, Crandall et al. 2018, Krebs 2010	12

White	Rappold et al. 2019, Johnson et al. 2018, Domroese and Johnson 2017, Merenlender et al. 2016, Wright et al. 2015, Grace-McCaskey et al. 2019, Larson et al. 2020, Frensley et al. 2017, Cox et al. 2018	9
European and North American	Krebs 2010, Curtis 2015, Jordan Raddick et al. 2013	3
Chronic health conditions	Rappold et al. 2019, Aoki et al. 2017	2

Figure 2: Participants' overrepresentation in citizen science projects

A large portion of studies find that participants are affluent, older, educated and living in North America or Europe. This is an issue for two reasons. First, our understanding of why individuals participate and how to increase participation may be biased towards those demographics already participating. This could **further exacerbate the disproportionate representation** in citizen science projects and research about them. Second, participating in citizen science can have many benefits, and as the (under)representation in citizen science follows the same pattern as general societal inequalities, **citizen science worsens these inequalities**.

Pandya (2012) developed a framework for **increasing the diversity** of participants in citizen science, especially with regard to lower income demographics and ethnic and racial minorities. Sorensen et al. (2019) share their experiences in attempting to apply Pandya's framework to a citizen science project about mosquitos in a lower income neighborhood. This was the only study in our literature review that attempted to increase underrepresented demographics in citizen science and gathered data not just from those who did participate but also those who did not. The authors concluded that there was little interest in the citizen science project as there were issues in the neighborhood which were deemed more important than mosquitos by community members.

2.2.3 Social factors

This section focuses on studies that have analyzed social interaction in CS projects, both between participants and between coordinators and participants, and its influence on an individual's participation. Several studies found that although social factors were not the most significant motivation for participating, it was a **significant motivation for a portion of participants** (Phillips et al. 2019, Ng et al. 2018, Merenlender et al. 2016, Alender 2016, Reed et al. 2013, Larson et al. 2020, Bell et al. 2008) and is one of the factors that is important for a sustainable and rewarding project (Singh et al. 2014). **Lack of social interaction** can also be a reason to stop participating (Ng et al. 2018, Frensley et al. 2017, Holohan and Garg 2005). In online projects, social factors seem to be much less important (Nov et al. 2013, Land-Zandstra et al. 2016a, Land-Zandstra et al. 2016b), with the exception of the study by Reed et al. (2013).

There seems to be a positive link between **long-term participation** and social interaction: social involvement can lead to repeated contributions (August et al. 2019), and longer term participants report being motivated by social interaction (Carballo-Cárdenas and Tobi 2016, Larson et al. 2020). Social interaction might not increase all types of participation, however, as one study found a negative correlation between contribution quantity and being motivated by social factors (Cox et al. 2018).

Social interaction in a citizen science project has two main forms: **between participants and project coordinators or among participants.** The first - ongoing assistance and interaction with project coordinators - is important for participation (Richter et al. 2018, Cappa et al. 2016, Baruch et al. 2016, Rotman et al. 2014). The second form - social interaction among participants - is also important, for two reasons.

The first reason comes from **Legitimate peripheral participation theory**, which postulates that newcomers observing longer term participants is an important aspect in them becoming full participants (Lave and Wenger, 1991). Observing long term participants allows newcomers to determine if they want to participate, and how to participate in the community, and is critical for participants transitioning to longer term engagement (Jackson et al. 2015). The second reason is based on **Social comparison theory**, which centers around the effects on behaviour due to a person's opinion and appraisal of their abilities with respect to others (Festinger 1954). Social comparison theory predicts that individuals will act to match the abilities of better performing others as long as they are not too divergent from themselves. This prediction is supported in the context of citizen science by a number of studies (Diner et al. 2018, Preist et al. 2014, Nakayama et al. 2019, Laut et al. 2017).

How can we include social factors in an online citizen science project? One way of doing so is through an **online project forum**, as some argue (Lin et al. 2016, Tinati et al. 2017). There is a positive correlation between individual's participation on the project forum, and their contribution quantity in the project (Eveleigh et al. 2014, Reeves and Simperl 2019, Luczak-Roesch et al. 2014).

2.3.4 Feedback

Giving feedback to participants on project performance is commonly found to improve participant retention: feedback is stated as being important for participants to **continue participating** (Geoghegan et al. 2016, Rambonnet et al. 2019, García et al. 2019, Baruch et al. 2016, Krebs 2010). The reverse also seems true: a lack of feedback or infrequent communication can lead to a decrease in participation (Killion et al. 2018, Freitag 2017, de Moor et al. 2019), and can even be a reason to quit the project (Eveleigh et al. 2014). Providing regular feedback can also have a positive effect on participation quantity, can make participants feel more included, and increase the interaction between participants (Aristeidou et al. 2015).

Feedback can take several forms. First, it can take the form of **dissemination of project results**, for example in blogs, reports, newsletters, etc. Dissemination of results is important for participants to show them how their data is being used (Golumbic et al. 2019), and can even be a prerequisite

for continued participation for some participants (Land-Zandstra et al. 2016, Domroese and Johnson 2017, Tinati et al. 2015). Dissemination of results does not only benefit longevity of participation, but also the quantity of participation. Studies have shown that there are spikes of engagement at the launch of projects and each subsequent time it is advertised (Spiers et al. 2019).

Second, **gamification** can serve to provide regular feedback to volunteers, besides adding a competitive element to the project. Gamification elements can assist in sustaining engagement over time, partially by providing meaningful recognition of achievements and contributions of participants (Iacovides et al. 2013, Eveleigh et al. 2013, Darch and Carusi 2010).

Third, **individual feedback on task performance** can improve participation. Feedback on the usefulness of participants' contributions at the right time can increase the quantity of participation (Kamar et al. 2016), and increases participation quality because it allows for learning (van der Wal et al. 2016). Why is feedback important to participants? Some studies find that participants are motivated by being recognised for their participation, but that showing participants that their contributions are useful and being used is more important than being recognised for their time (Rotman et al. 2012). Others do not find that recognition is important at all (Alender 2016).

2.3.5 Recruitment

A diversity of results exists on the effectiveness of **different methods of recruiting** on increasing participation. The most successful method of recruitment will highly depend on the characteristics of the project. Some studies find word of mouth is less effective than other methods (Jakositz et al. 2020, Holohan and Garg 2005, Robson et al. 2013), while other studies found word of mouth was highly effective (García et al. 2019, Ng et al. 2018, Aristeidou et al. 2015). Both online and offline projects seem to benefit from online recruitment: through a facebook campaign (Robson et al. 2013) or forums, news websites and other websites (Holohan and Garg 2005), or email (Andow et al. 2016).

Several **citizen science platforms** exist, and these seem beneficial to recruiting participants. Crall et al. (2017) even found that a project was able to meet its campaign goal in less than 24 hours by emailing other project participants on the Zooniverse platform. Additionally, connections with partners and affiliated organizations increased the number of contacted individuals for the recruitment campaign by around 45 times. Other studies similarly found that partner organizations and citizen science platforms were important in recruiting volunteers (de Moor 2019, Ponciano and Pereira 2019). Collaborations with other institutes does not only benefit recruitment, but also the general success of the project: successful projects often include diverse stakeholders and collaborate with multiple institutions (Chase and Levine 2016, Loos et al. 2015).

Some projects aim to increase the diversity of their participants. Brouwer and Hessels (2019) argue that the method of recruiting participants for a citizen science project can influence the diversity of participants. A **targeted recruitment strategy** was developed and was able to recruit more people with a lower level of education. Similarly, Rich (2019) increased minority groups participation by 20-25% over 5 years through collaboration with community organizations and

publishing reports in multiple languages. Herodotou et al. (2020) found that a project that actively tried to recruit younger people also had more young participants than other projects on the Zooniverse platform. However, some projects are also unable to increase the diversity of their participants: Ferster et al. (2013) tried to recruit people without a professional background in the topic, but most participants still had a professional background in the topic.

The **messages used in recruitment** also appear to be important. Some studies find that appealing to specific motivations for participating is successful (Crimmins et al. 2014), and that messages mentioning contributing to science and learning were most successful while messages mentioning joining a community were least successful (Lee et al. 2018). Those who were recruited using the motivational messages contributed significantly more than those who joined in the same period but did not receive a motivational recruitment message. It is possible however that a selection bias exists: it could be that the message was selecting participants who participate more rather than motivating participants to participate more.

2.3.6 Task design

Instead of studying participants, some studies analyze the tasks within the projects to determine what makes the project successful or unsuccessful. Several themes emerge from the findings.

What types of projects work well as citizen science project? The study should be **about something that is important** (Chase and Levine, 2016), **or interesting** (Golumbic et al. 2019) to those who will participate. For example, projects that involve searching images for occurrences (such as animals) need to make sure the “hits” (pictures which contain the animals) do not occur too little or too often, otherwise participants lose interest (Tinati et al. 2015, Bowyer et al. 2015, Alexandrino et al. 2019). A study that tested the novelty factor found that receiving a message that the volunteer was the first to see an image resulted in increased quantity of participation, even for those who only participated one time (Jackson et al. 2016). In addition, varying the species of animals can increase participation (Alexandrino et al. 2019, Tulloch et al. 2013), and some found that image classification tasks typically perform better than audio based tasks (Tinati et al. 2015).

Projects should also be **beneficial** to its participants (Bowyer et al. 2015, Singh et al. 2014, Wood et al. 2011, Sullivan et al. 2013). Projects should have a specific goal, whether that is education, community engagement or the creating scientific datasets (Rambonnet et al. 2019, Grodzinska-Jurczak et al. 2018). Golumbic et al. (2019a) and Cox et al. (2015) specifically found that projects with a scientific goal that produce impactful data were most successful. Chase and Levine (2016) found that having both a scientific and education or community engagement goal can sometimes conflict.

How should the tasks be designed? Several studies stress that tasks should be **quick and easy** to perform (Rambonnet et al. 2019, Tinati et al. 2015, Grodzinska-Jurczak et al. 2018), have locations that are easily accessible by participants (Chase and Levine 2016, Alexandrino et al. 2019) and requiring little to no training or prior knowledge (Golumbic et al. 2019a). Furthermore, it should be easy for participants to sign up to a project (Jay et al. 2016, Crall et al. 2017), the user interface

should be user friendly (Golumbic et al. 2019a) and flexible (Sullivan et al. 2013, Golumbic et al. 2019b).

While it appears that for some projects and especially for initial participation tasks should be quick and easy to perform, projects can also be successful that require **more upfront commitment and involvement**. For example, providing education or training as part of projects (Golumbic et al. 2019a, Loos et al. 2015, Grodzinska-Jurczak et al. 2018, Wood et al. 2011), or giving participants more responsibility can be successful (Loos et al. 2015). In a similar vein, participants should be able to be involved in decision making (Singh et al. 2014). Participants like to think along. Tinati et al. (2015) found that including contextual information on data that needs to be analysed can increase participant engagement: in the project they studied this led to increased engagement and significant discussions between participants.

2.2.7 Barriers

Instead of taking the perspective of why people participate, several studies have examined barriers to participation or reasons for stopping to participate. Predictably, **lack of time** is often cited as a barrier to participation (Martin and Greig 2019, Richter et al. 2018, Aristeidou et al. 2017, Domroese and Johnson 2017, Merenlender et al. 2016, Everett and Geoghegan 2016, Martin et al. 2016, Frensley et al. 2017, Kleinke et al. 2018, Cooper et al. 2017, Geoghegan et al. 2016, Rotman et al. 2014, Leao and Izadpahani 2016, Gharesifard and Wehn 2016). Although lack of time was found as a barrier to participation by the most number of studies, some studies found that other factors were more significant barriers. Martin et al. (2016) found that perceiving to have **inadequate knowledge** was the biggest barrier to participation or the difficulty of the task. Perceived lack of knowledge or difficulty of the task was also found to be a barrier by other studies (Gharesifard and Wehn 2016, Kleinke et al. 2018).

Studying people who do not participate in citizen science demonstrates that the most significant barrier to participating is a **lack of awareness** (Hermoso et al. 2019, Lucrezi et al. 2018, Hobbs and White 2012, Crandall et al. 2018). Further barriers were cost of participating (Martin and Greig 2019, Hobbs and White 2012, Gharesifard and Wehn 2016), health (Ng et al. 2018), poor user interface (Aristeidou et al. 2017, Frensley et al. 2017, Crandall et al. 2018), not having access to technology (Rotman et al. 2014, Leao and Izadpahani 2016, Gharesifard and Wehn 2016), having their monitoring partner leave or lack of social interaction (Ng et al. 2018, Frensley et al. 2017), perceiving the study to not be relevant or deliver results (Frensley et al. 2017, Sorensen et al. 2019), among others.

2.3 Input for guidelines

The systematic literature review provides input for practical guidelines and tools for community engagement and monitoring (see chapter 5). In this section, we describe how the findings of the literature review feed into these guidelines.

The results from the literature review are the first and main source of input for the guidelines, and will be supplemented by findings from the case study (chapter 3) and the workshop (chapter 4).

We decided to start from the themes that emerged from the literature review. In order to end up with a practicable list of guidelines, we needed to condense the categorisation of findings, because some similar practical advice emerged from different themes. For example, in the theme “barriers” we wrote that perceived lack of knowledge can be a barrier for participation, which is actually in line with what we wrote in the section “self-efficacy”, in that alleviating anxiety about task performance can improve participation. In figure 3 we show this process for each of the guidelines.

Themes from literature	Process	Guidelines
Self-efficacy	Main input for guideline 1	1. Increase self-efficacy
Demographics	Main input for guideline 2	2. Increasing diversity and accessibility
Social factors	Main input for guideline 3	3. Social interaction between participants
Feedback	Additional input for guideline 1 and for guideline 5	
Recruitment	Main input for guideline 4	4. Recruitment
Task design	Main input for guideline 5	5. Appreciation and importance
Barriers	Additional input for guideline 1, 2, 3, 4, and 5	

Figure 3: Process for developing guidelines

3 CASE STUDY: PARTICIPATION IN CITIZEN SCIENCE PROJECTS

In this chapter we report on a case study of the Dutch Butterfly Conservation, for the full case study, see Groen (2020). The goal of the case study was to find out to what extent the framing of a project has an influence on the citizens' framing of this project. By *framing* we mean a way of interpreting and simplifying reality. In this context all the activities of a citizen science project can be interpreted, simplified, and communicated in a certain way.

Framing is thought to have an effect on how people understand and respond to events: the choices they make are influenced by how they interpret and simplify reality (Goffman 1974). We decided to apply this approach to citizen science, because from the literature review it appeared that the reasons and motivations that participants state for their participation often seem to align with the way in which the project is communicated. We hypothesise that the project's framing aligns well with the participants' framing of the project. If this is true, this is an indication that the framing of the citizen science project has an effect on the way the citizens frame the project, or vice versa, or both. This finding could then have consequences for whether and how volunteers participate: the project's framing can attract a certain group of citizens, determine in which way they participate, and for how long. To our knowledge, this angle on participation in citizen science has not yet been researched. Due to the limited number of interviewees (see 3.2) this will be an explorative study that can lead to further research. In addition, the findings in this study will serve as input for the guidelines in chapter 5 (see 3.3).

3.1 Case: Dutch Butterfly Conservation

The Dutch Butterfly Conservation (DBC) is an organization that aims to increase the amount of butterflies and moths and includes a citizen science program to monitor the distribution and wellbeing of butterflies. Following the framework developed by Bonney et al. (2009), the citizen science project is a contributory project. The citizen science project was started in 1990 in collaboration with Statistics Netherlands (Centraal Bureau voor de Statistiek), the Dutch governmental institution for collecting statistics for supporting policy development and decision making.

There are three different programs, one for butterflies, one for moths, and one for dragonflies. The program for butterflies is the oldest and has the most participants. For the butterfly program, participants, or counters, walk predefined routes and count the sightings of butterflies in their specified area. For some routes participants count all butterflies, whereas others only count specific species that are of interest. Participants must complete the route once per week from April to September, however, the participants can choose the specific days and times they count provided certain weather conditions are met. The dragonfly project is the second oldest and was started in 1998. The dragonfly program functions similarly to the butterfly program, however, the project coordinators feel dragonflies are harder to count as there are more species and they move

quicker. The most recent is the moth program which was started in 2012. Participating in the moth project used to require staying up during the night, however, recent advancements in measurement techniques makes participating significantly easier. Participants now place a trap with a special light that attracts moths and collect the trap in the morning to count and release the moths. A recent initiative has also collaborated with farmers to also include farmland in their assessments as previously data was mostly collected in parks and backyards.

When a potential participant decides to participate, a staff member often goes and personally visits that individual to help create a route and explain the project to them. It is also possible that prospective participants set their own route, or a local group, run by participants, introduces and sets up new participants with routes. This labour-intensive process of introducing new participants to the project is quite exceptional in citizen science. In addition, and possibly related, participants actively contribute for quite a long time to the DBC project - an average of 8.80 years (see Reeves et al. 2020). After outlining the methods and results of this case study, we reflect on these aspects and how they relate to the guidelines for increasing participation.

3.2 Methods

The research for this case study can be divided into two sections: project framing analysis, and participant interviews. The framing analysis was used to analyze the framing of the project. The participant interviews were conducted to determine how participants framed their participation in the project. What follows is a detailed description of the methodological choices made for each section.

3.2.1 Framing analysis

For analysis of the project framing a combination of a framework developed by Snow and Benford (1988) and Matthes and Kohring (2008) was used. The framework used can be seen in figure 4. The problem definition, causal interpretation and moral evaluation framing elements were drawn from Matthes and Kohring's framework and the prognosis and motivational messages framing elements were drawn from Snow and Benford. Each framing element has a series of questions which were used to code the texts. A posteriori coding was used to allow the codes to emerge based on the text themselves.

For the framing analysis we used the website of the project. As the citizen science project is only one aspect of what the DBC does, we only included those pages relevant to the citizen science project. The researcher attempted to mimic how a prospective participant would browse the website to result in a sample of the framing used by the DBC similar to what participants may view. The main webpage we used was https://www.vlinderstichting.nl/wat-wij-doen/meetnetten and other pages directly clickable from that page.

Framing Element	**Questions**

Problem Definition	What is the topic and problem that the project addresses? Who are the actors involved?
Causal Interpretation	Who is responsible for the risks of the project? Who is responsible for the benefits of the project?
Moral Evaluation	What are the benefits of the topic that the project addresses? What are the risks of the topic that the project addresses?
Prognosis	What are the suggested solutions to the problem? What are the strategies, tactics, and targets?
Motivational messages	Why should someone participate in this project?

Figure 4: framing elements and associated questions

3.2.2 Interviews

We conducted semi-structured interviews with participants. We used a hybrid between the two frameworks (Crowston & Fagnot 2008 and Penner 2002) to develop the interview guide. We included three stages of participation: decision to participate, initial participation, and sustained participation. We asked open questions about each stage of volunteering along with more specific questions based on the hypothesis developed in the frameworks. We posed questions as open as possible to minimize influencing participants. Additionally, we used an introductory question to very openly ask about the individuals participation in the DBC project.

We made notes of the interview along with recordings when possible. We coded the audio recordings or notes using the same framework as we used for analysing the project framing, with one modification. We modified motivational messages to reflect the participants' perspective and used the frameworks of Crowston and Fagnot (2008) and Penner (2002) to reflect multiple stages of participation. The framework used is the same as for the project framing, replacing the question for motivational messages with "Why did the participant start participating?" and "Why did the participant continue to participate?".

We selected participants from the DBC with help from the project coordinators in order to include a diversity of participants in terms of how long they have been participating and in which program they participate. We conducted a total of 7 interviews; four interviews were conducted during the annual participants meeting of the DBC, while the other three were conducted online or via telephone.

Limitations of the research are the limited sample size both in terms of the number of participants included and the projects analyzed. Several attempts were made to include other projects in this research however, due to the covid-19 crisis and other circumstances, we were only able to include one project. This limits the findings as conclusions can only be made for the small sample size of participants within the one project that was analysed. However, since the purpose of this research is more exploratory, it is still relevant as it is the first to study framing in the context of citizen science. Future research will need to be conducted to refine the methodology and apply it to larger sample sizes and more projects.

3.3 Results

3.3.1 Dutch Butterfly Conservation project framing

3.3.1.1 Problem definition

What is the topic and problem that the project addresses?

The topics identified are butterflies and collecting data about butterflies. The primary problem that is identified is that there is a decline in butterfly populations: “in the past you saw far more butterflies” (all quotes in 3.3 are translated from the website, accessed in May 2020). It is further emphasized that there are fewer species of butterflies present and those that are still present are endangered: “since the beginning of the twentieth century seventeen types of butterflies have disappeared from the Netherlands”.

What actors are involved?

The actors mentioned on the website as involved in the topic are: the DBC, Statistics Netherlands (CBS), BIJ12, European Invertebrate Survey NL (EIS), government (from local to international), land owners, businesses, and the volunteers of the citizen science project. The three actors that are mentioned most often are the DBC, their volunteers, and Statistics Netherlands (CBS).

3.3.1.2 Causal Interpretation

Who is responsible for the risks of the project?

There are no explicit mentions of actors who are responsible for the risks. It is implied that human development and land management are responsible for causing the decline of butterflies. However, these actors are only very vaguely implicated. For example: “what happens to the butterfly population if the grass is mowed” which only implies that those who would mow the grass

may cause negative effects for butterflies. Furthermore “many suitable places [for butterflies] have had to make way for houses, roads, industry and agriculture” implies human development in general is responsible without accusing specific actors. Pollution is also identified as a potential risk for butterflies however the responsible party is once more unmentioned “what effect does nitrogen [pollution] have on butterflies”.

Who is responsible for the benefits of the project?

The only two actors who are directly stated as being involved in a positive way are the DBC itself and the volunteers. The DBC “has already achieved different successes”. Volunteers are framed as: “the most important participants to the project are of course the many volunteers… without them the monitoring project would not exist”. While other actors are mentioned as being involved, they are not directly framed positively or responsible for benefits.

3.3.1.3 Moral Evaluation

What are the benefits of the topic that the project addresses?

Butterflies are framed as a symbol of nature, joy and beauty; “butterflies are *the* symbol of beauty and joyfulness”. It is expressed that areas with lots of butterflies are a sign that nature is healthy in that location. Solving the issue of butterfly decline is framed as allowing future generations to enjoy the beauty of butterflies even more than we do.

What are the risks of the topic that the project addresses?

The risks of the topic are simply framed as that butterflies could disappear, especially rare types of butterflies. No further mentions are made of what risks this presents.

3.3.1.4 Prognosis

What are the solutions to the problem? What strategies, tactics and targets are identified?

The solution to the problem is presented as monitoring butterflies, especially in a consistent and scientific manner. The gathered data is depicted as allowing the DBC to provide advice to policy makers and government to protect butterflies. Further mentions are made of working together with land owners and businesses to protect butterflies. Finally, education and awareness raising are broadly suggested as solutions to the problem. The only mention of a target for the citizen science project is the “gathering of information about changes in the butterfly population in the Netherlands”. A broader goal for DBC as a whole is to have butterflies everywhere where they should be.

3.3.1.5 Motivational Messages

Why should someone participate in this project?

The framing of why someone should participate mostly focuses on having an interest in butterflies and their protection. Someone should participate to protect butterflies because they like butterflies

and have some prior knowledge. In a call to action the website states: “do you have reasonable knowledge of the butterflies or dragonflies in your area…?” and “would you enjoy walking a route [to count butterflies]?”. There are mentions of ensuring that future generations will be able to enjoy just as much as us; “we want that in a hundred years our great grandchildren can enjoy the beauty of butterflies”. There is a group or social element included in that it is enjoyable to count butterflies with others in a group. Finally, participation is presented as a way to protect butterflies so that “causes and changes can quickly be reversed” by the DBC.

3.3.2 Participants’ Framing

3.3.2.1 Problem definition

What is the topic and problem that the project addresses?

All participants mentioned that the problem was that butterflies/moths are not doing well with one participant framing it as a more general decline in biodiversity. One participant further specified this issue as that there are fewer nectar plants for butterflies, two participants mentioned NO_x as a problem, and two identified land development as a problem. One participant mentioned that there were not enough participants in the moth monitoring project of the DBC which was communicated to him by DBC staff.

What actors are involved

All participants referred to the DBC, and five made mentions of fellow volunteers. The following actors were mentioned by one participant: municipalities, provincial government, Naturalis, IVN, land owners, and forest managers.

3.3.2.2 Causal Interpretation

Who is responsible for the risks of the project?

Only one participant identified a responsible party for the risks and negative consequences: land owners. At the same time, land owners collaborate in protecting butterflies.

Who is responsible for the benefits of the project?

There are not any clear mentions of who is responsible for the benefits. There are mentions that the DBC is a well run organization, but it is not explicitly tied to benefits. One participant did however express that the DBC should be more involved in assisting its volunteers in discussions with land owners to convince them to use land practices which are better for butterflies, which would be a new activity for DBC.

3.3.2.3 Moral Evaluation

What are the benefits of the topic that the project addresses?

Only one participant made an explicit statement about benefits of the topic, which was an increase in biodiversity.

What are the risks of the topic that the project addresses?

The only risk associated with the problem is expressed as there being less butterflies. No participants further extrapolate what risks or consequences this could entail.

3.3.2.4 Prognosis

What are the solutions to the problem? What are the strategies, tactics, and targets?

All participants mention that monitoring butterflies/moths is the solution to the problem. Four participants further specify that the monitoring has to be done consistently over a long time scale to be effective. One participant mentions working together with land owners to adjust land practices to increase the population of butterflies.

3.3.2.5 Motivational Messages

Why did you start participating?

Common themes in the reasons participants stated for joining are an interest in nature or butterflies, believing that conservation and monitoring are important and that this project is useful.

Why do you continue to participate?

Common themes in why participants continued to participate are that the activities in the project are enjoyable, that it is important to monitor butterflies, and because their contribution to conserving butterflies is important. One participant has started to feel a sense of ownership for their route. Each participants' reasons are discussed in more length below.

3.4 Input for guidelines

From the results described in 3.3 it appears that there is substantial overlap in the project's framing and the participants' framing of the project. Because of the small dataset, we cannot make any final conclusions about whether the participants choose a project because of its framing or whether at least the framing directly influences how they interpret their participation and the project at large, but the results do indicate that the framings align.

It is unclear whether there is a causal process between the framings. It could be that the project's framing influences the participants' framing of the project, or vice versa, or both, or none. The possibility that the project's framing influences participants' framing of the project indicates that project managers should reflect on the framing of their citizen science projects, which is why we added "framing" as the sixth guideline for increasing participation.

Another finding of the case study that feeds into the guidelines is that many participants have indicated that they find the goals of the project important, and that their part in supporting that goal is also important. This aligns well with the guideline “appreciation and importance” described in 5.5.

4 WORKSHOP

As a third way to collect data and insights on how to increase participation in cs projects, we hosted a workshop on 'Participation in citizen science projects' during the accelerator kick-off workshop organized by ACTION in February 2020. This workshop served to validate guidelines that we developed based on preliminary results from the literature review, gather perspectives on different forms of participation as well as actual examples and methods for increasing participation.

4.1 Methods

During the workshop, we presented six guidelines for increasing participation: gamification, social interaction, communication, accessibility, collaboration with organisations and institutions, and aligning with community goals. These guidelines are similar to the guidelines that we describe in chapter 5, but not the same. The reason that they are different is that at the time of the workshop, we had not finished the literature review, which means the guidelines we presented there were based on preliminary findings from the literature review.

During the workshop, we first explained the guidelines. The exercise then consisted of two parts. For the first part, we asked participants the question: “How could you use these kinds of guidelines to increase participation?” and asked them to write down examples of these tools that they think or know will work. For the second part, we asked participants to read everyone’s examples and mark them in terms of what kind of participation would be increased. The kinds of participation corresponded to the typology in the introduction: long-term versus short-term, more people versus more contributions, increased quality versus increased quantity, and increasing participation of specific groups versus anyone. All participants were invited to mark all the examples with as many types of participation that they saw fit.

The number of participants was 12, and the group consisted of project managers of the new ACTION pilots, as well as people in the ACTION consortium.

4.2 Results

Figure 4 reflects the results of the workshop.

Guideline	**Tool/example (results from exercise 1)**	**Kind of participation (results from exercise 2)**
Accessibility		Specific groups
Accessibility	Regular meetings with food, and accessible info in FAQ sheets, tasks, infographics	Long-term, Quality
Align with community goals		More people, Long-term
Alignment		Specific groups, Long-term

Collaboration	Connecting with social groups like local volunteering groups and local NGO's	Everyone
Communication	Visual communication, graphic design	Quantity, Quality
Communication	1 on 1, newsletter, reports	Long-term
Communication	Disseminate project results with the feedback of volunteer participants	Everyone
Communication (?)	Launching competitions with a prize	More people, short-term, More contributions
Communication & Social interaction	Check-ins: "what kind of vegetable/animal do you feel like today". Check-outs: reflecting onto what happened	Long-term, Everyone
Community priorities		Quality
Cooperation with other organisations		Specific groups, Long-term
Gamification	Giving recognition to volunteers on project webpage, links on social media to the website tagging contributors	Long-term, More contributions
Involving other organisations	For recognition and networking	
Social interaction	Public events: invite "experts"/passionate people about the topic	Specific groups
Social interaction	Meetings, start together setting up	Quality
Social interaction	Workshops at schools/science fairs	Quality, Specific groups, More contributions
	Lots of care over food - take hardest person and cater everything for them (but no need to mention it). Also use local up&coming chef	Specific groups
	Score points for schools	Specific groups, More people
	Keep in touch with the expert (via forum?)	Long-term, Everyone, Quality
	Workshop. Hands on session with the experts	Quality, Everyone, More contributions
	Avoid any links to formal institutions, e.g. no uni logos, never in a formal learning environment	
	Design for introverts! Extroverts will always be ok. (we avoid icebreakers completely for this reason)	Everyone
	Use flowers, music, good lighting, comfy seats etc to make people more	More people

	comfortable and know they are respected/valued	
	Project users to the future, shaping their life thanks to the project	Long-term
	Involve other schools who are doing the same project	More people
	Building Identity - choosing a name, drawing a logo, making a uniform with these logos, creating a playlist	Long-term
	Bring clarity - what is my role, what is the process looking like, how do I contribute to the overall process	Long-term
	Engaging through shared experiences - going on a trip together, cooking and eating together	Long-term

Figure 5: Workshop results

Here we can see that some people have marked their examples as part of a specific guideline, whereas others have not. All but one of the examples were marked for specific types of participation.

4.3 Input for guidelines

From this intervention, we validated the guidelines that we developed based on preliminary results from the literature review: none of the guidelines seemed irrelevant to the participants, which means they were taken up (sometimes in adjusted form) in the final set of guidelines. Second we gathered actual examples and methods for increasing participation, which will be included in the online tool that we develop (see chapter 6).

5 Towards a tool for increasing participation

5.1 Synthesizing the guidelines

In this chapter, we will describe the guidelines for increasing participation, as well as the next steps for turning these guidelines into an online tool that is part of the ACTION toolkit.

5.1.1 Increase self-efficacy

Participants often experience anxiety about whether they are performing their tasks in the right way. This anxiety influences their participation, which means that to increase participation, project managers can alleviate this anxiety and increase participants' self-efficacy. Perceived lack of knowledge is also a significant barrier for participation. Participants need to feel apt to do their tasks, and this often leads to longer term participation. Besides participation retention, increasing self-efficacy can also lead to higher quality of participation.

How can project managers increase participants' self-efficacy? The main guideline is to make participants feel that they are doing a good job. There are two ways to do this. First, by teaching them how to perform their tasks, by giving clear instructions, for example in tutorials. Second, by letting them know they can make mistakes, for example by telling them that there are multiple people performing the same task, which means that making a mistake will not be detrimental to the project.

Increasing self-efficacy does not necessarily need to be done through communication with the project managers: it can also be through communication between participants. By making space for communication between participants, more experienced participants can teach other participants how to perform the tasks and thus increase their self-efficacy.

5.1.2 Increasing diversity and accessibility

On average, citizen science projects are not very diverse in terms of demographics. The main domains in which the demographics of the participants are skewed are age, educational background, gender, race, cultural background, and (dis)ability - the "average" participant of a citizen science project being older, highly educated, male or female depending on the project, white, from Europe or Northern America, and able-bodied.

One way to increase diversity and participation in general is to improve accessibility of the project. This can be accessibility in terms of location, language, finances, technology, and the level of knowledge required. In other words, reducing barriers in these areas can lead to more people participating.

Other means to increase diversity is to align the activities in the project with community goals, to engage the community at every step of the project, and to incorporate multiple kinds of knowledge (Pandya 2012). Again, this does not only lead to increasing diversity of participants, but also increases the number of participants in general.

5.1.3 Social interaction between participants

Social interaction between participants can lead to increased number of contributions, increased number of participants, and long-term participation. Opportunities for social interaction are especially promising for retaining participants on the long-term participation, and the lack thereof can be a reason for stopping to participate.

More specifically, providing the opportunity for social interaction with more experienced participants is important for recruiting new participants as well as for increasing the number of contributions of new participants. Furthermore, allowing for social interaction with someone who is participating a little bit more, can also lead to increased contributions for those participants that can identify with that person.

5.1.4 Recruitment

Recruitment strategies are important. Recruiting participants via citizen science platforms is very effective. The medium of recruitment, whether it is word-of-mouth or via official channels, does not seem to have an unequivocal effect on participation; it varies per project what the best medium for recruitment is. The message for recruiting does seem to have an effect on participation, even though the exact content will also differ per project.

Furthermore, appropriate recruitment strategies can lead to increased diversity of participants. Targeting different groups, as well as increasing accessibility of the project can diversify the group of participants.

5.1.5 Appreciation and importance

Appreciating participants and acknowledging the importance of their work can lead to increased contributions from participants. Not only the participants' individual work, but also the project's goals need to be seen as relevant, in order to increase participation (or prevent participants from quitting the project).

The main way to appreciate participants and to stress the importance of the project and their contributions in it is to give feedback. This can be individual feedback, or general dissemination of results of the project. In this way, participants can feel that they are part of something important. Another way to enhance this is to give participants more responsibility in the project.

5.1.6 Project framing

Project framing can potentially have a positive effect on participation in a citizen science project. The problem, goals, moral evaluation, and messages that project coordinators send out about the project might influence the type and extent of participation of the citizens. In addition, once participants have adopted a certain framing of the project, they might respond to different interventions in accord with that framing. For example, the message sent while recruiting new participants is part of the overall framing of the project (or at least should be), and then subsequently can have an influence on whether people participate and how.

5.2 Next steps

All the data described in this deliverable serves as input for a tool about increasing participation that will be part of the ACTION online toolkit. In this section we describe the next steps that will lead to this tool, as well as a few areas of content that we want to improve.

The tool will connect the six guidelines and the types of participation, and will have several practical examples attached to these guidelines. In order to do so, we will take the data in figure 5 as a starting point, and supplement the data in three ways.

First, we will adjust the first column to the current version of the guidelines and add missing guideline categorisations of the examples given by participants. For example, the input given in the workshop “avoid any links to formal institutions, e.g. no uni logos, never in a formal learning environment” fits with the guideline “increasing diversity and accessibility”, because it eases access for participants of all educational backgrounds.

Third, we will add practical examples found in the literature. For example, from the systematic literature study it appears that allowing newcomers to observe and learn from more experienced participants can enhance long-term participation. We will categorise these examples according to our guidelines.

Fourth, we will open the floor to other citizen science projects to add their examples on two occasions. First, we will ask the workshop participants of ACTION’s next accelerator kick-off meeting in January 2021 for feedback. Second, we hope to do an open call via social media to expand the tool on the basis of insights and best practices from other citizen science projects.

We will make these guidelines and practical examples available as a tool on the ACTION website. We still need to finalise the exact layout and form of this tool, but the examples will be categorised both by guideline and by the type of participation. In this way, citizen science managers can search for the tools that would best fit their type of project.

6 CONCLUSIONS

This deliverable contains initial guidelines and tools for community engagement and monitoring as well as the research that led up to those. We showed how the six guidelines can increase participation: by increasing self-efficacy, allowing for social interaction between participants, focussing on recruitment, increasing diversity and accessibility, increasing appreciation and importance, and developing project framing. These guidelines can have an impact on various types of participation: they can be long-term and/or short-term, more people and/or more contributions, increased quality and/or increased quantity, and increasing participation of specific groups and/or anyone.

We supported the guidelines by evidence found in a systematic literature study and an in-depth case study of an existing and successful citizen science project. Furthermore, we have collected data on how to translate these guidelines into practical interventions to increase participation. These data will be supplemented in the future and form the basis of a tool that will be part of ACTION's online toolkit. As participation is at the core of every citizen science project, this deliverable and its associated tool contribute to ACTION's aim of supporting citizen science.

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